Announcements

- Assignment 1 posted on course website
  - https://coursys.sfu.ca/2019sp-cmpt-125-d1/pages/
  - Hard copy due before class next Wednesday (Jan. 16)
  - You may write or type your solutions
- No late submissions allowed
  - Lowest mark assignment will be omitted

Pointer, Functions, Performance

CMPT 125
Jan. 9

Lecture 3

Today:

- Data, pointers
- Functions in C
- Performance Measurements of Code

Data vs Pointers (Review)

- Besides its data and its type, a variable needs a memory location to place the data.
  - the variable’s <u>address</u> (a number)
  - each variable has a <u>distinct</u> address, i.e., they may not overlap
- The C language allows programs to store and manipulate these addresses
  - called a *pointer*

Pointer Operations in C

```c
int main ( ) {
    int area = 25;
    Int * pArea = &area;

    printf("area = %d\n", area);
    printf("pArea = %ld\n", pArea);
    printf("pArea = %lx\n", pArea);
}
```

Output:

```
area = 25
pArea = 140734562585432
pArea = 7fff519c4b58
```

- a "`*`" in front of the var name means *pointer*
- the "`&`" operator means "*address of*"
    - saw before when using `scanf("%d", &var);`

Pointer Operations in C

```
int main ( ) {
    int area = 0;
    Int * pArea = &area;

    *pArea = 25;
    printf("area = %d\n", area);
    *pArea = *pArea + 50;
    printf("area = %d\n", *pArea);
}
```

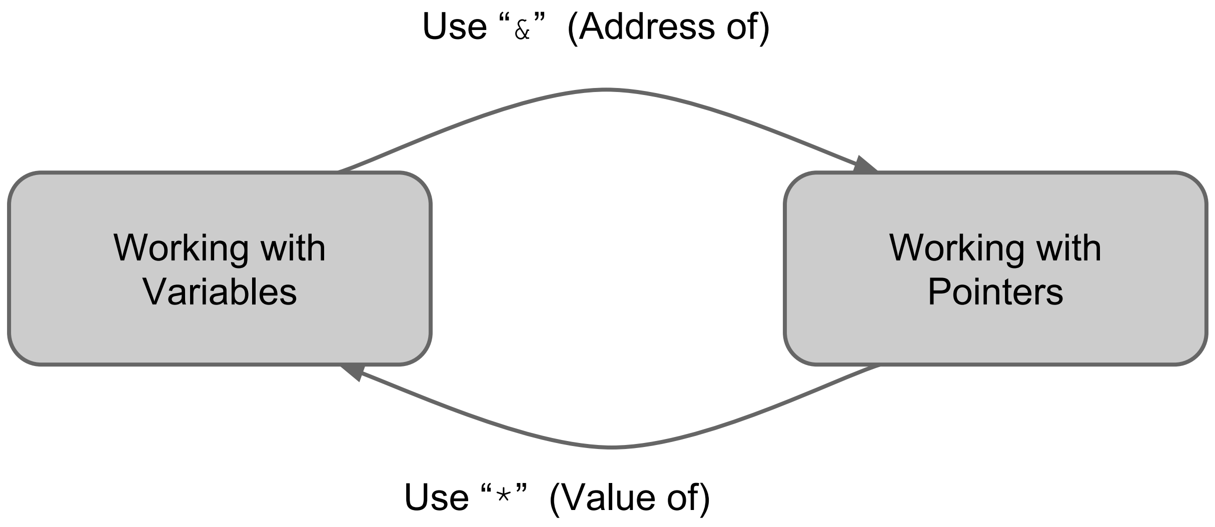
Output:

```
area = 25
area = 75
```

- the “*” operator means *dereference*
  - use / modify the data where the pointer points
  - “Value of”

Pointer Operations - Recap

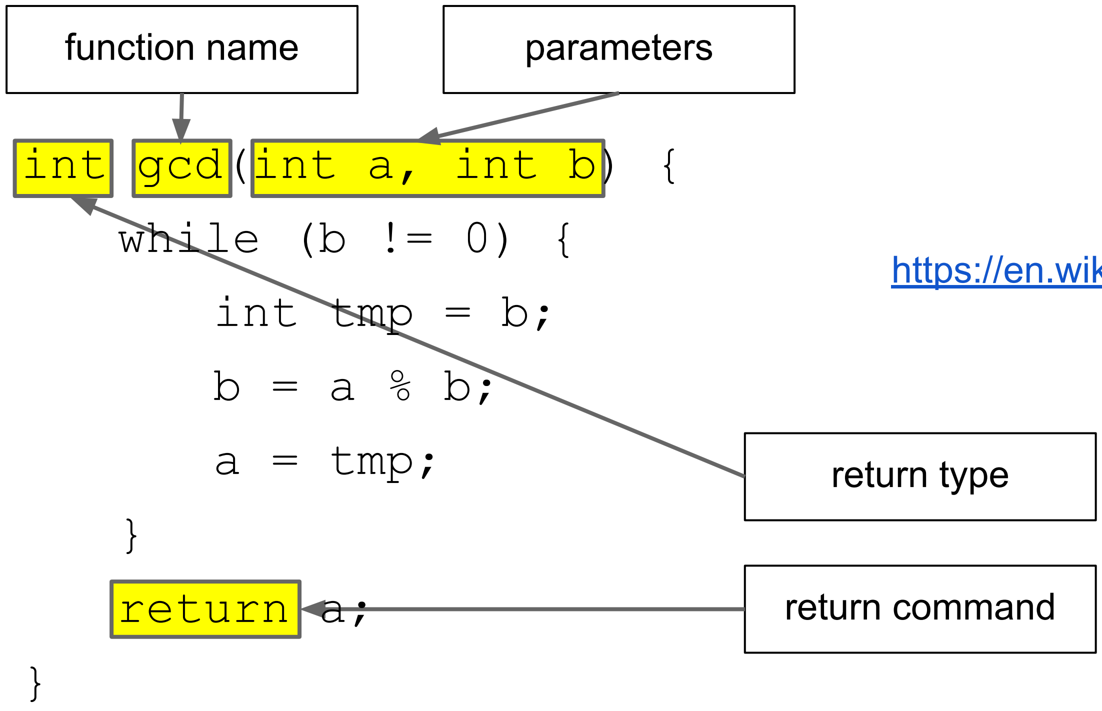
- Remember the difference between:
  - the data (variable)
  - the address (pointer)



Q. How are these operators related to each other?

Functions

- Define functions outside of main program
  - `main( )` is itself a function!
- Anatomy of a function:



```
int gcd(int a, int b) {
    while (b != 0) {
        int tmp = b;
        b = a % b;
        a = tmp;
    }
    return a;
}
```

https://en.wikipedia.org/wiki/Euclidean_algorithm

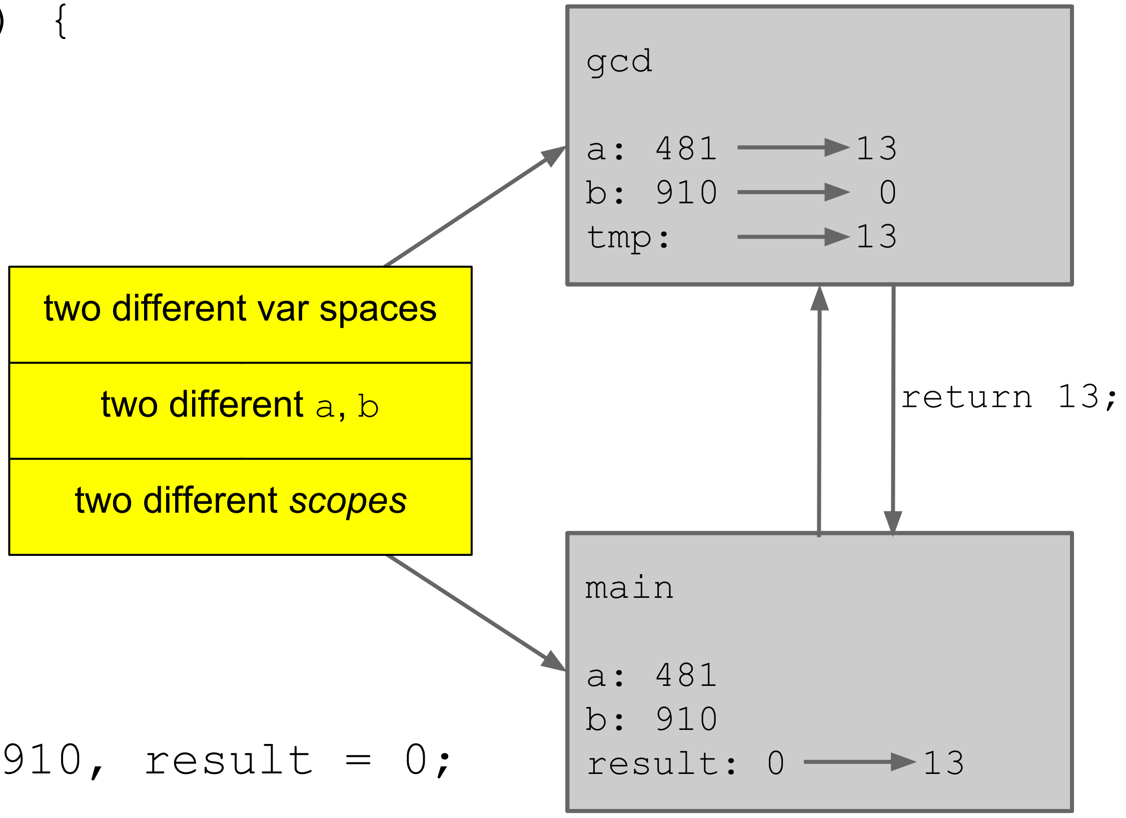
Pass By Value

- All functions in C pass parameters by value
  - call the subroutine, and it gets its own copy
    - each copy within its own *scope*
  - avoids *side-effects*: calling a function should not (unexpectedly) modify its parameters
- All functions in Python pass parameters by reference
- Java is a mix

Experiment

```
int gcd(int a, int b) {
    while (b != 0) {
        int tmp = b;
        b = a % b;
        a = tmp;
    }
    return a;
}

int main ( ) {
    int a = 481, b = 910, result = 0;
    result = gcd(a, b);
    printf("gcd(%d,%d) = %d\n", a, b, result);
}
```



output: `gcd(481,910) = 13`

Pointers as Parameters

To modify variables outside of scope, pass a pointer to that variable

```
void swap(int a, int b) {
    int tmp = a;
    a = b;
    b = tmp;
    return;
}

int main ( ) {
    int a = 5, b = 12;
    swap(a, b);
}
```

This won't change the values of `a`, `b` in the `main` routine. Only locally.

```
void swap(int *a, int *b) {
    int tmp = *a;
    *a = *b;
    *b = tmp;
    return;
}

int main ( ) {
    int a = 5, b = 12;
    swap(&a, &b);
}
```

Pass pointers to the integers instead, and use `*a` and `*b` (dereference) to access their values.

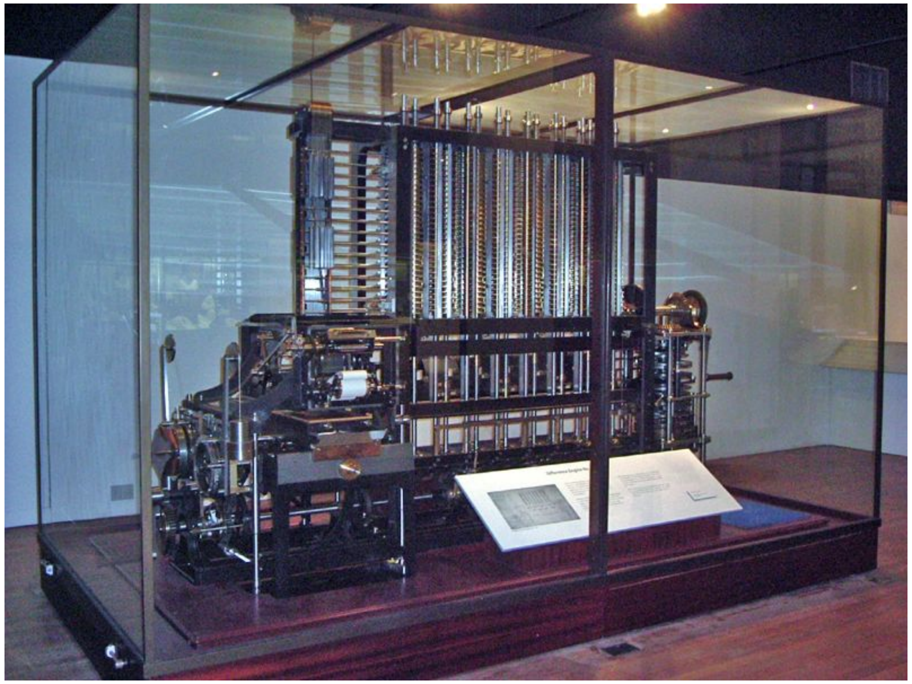
Functions - Summary

- Functions in C have similar syntax and operation to functions in Python
- Exceptions:
  - must define the types of all parameters
  - must define the type of return value
  - all parameters are pass by value
- Pass a pointer to modify a caller’s variable

Any questions?

How Good is Your Code?

- Several measures of “good”-ness:
- Is it . . .:
  - correct? (bug-free)
  - reliable?
  - efficient?
  - affordable?
  - maintainable?
  - easy to use?



How Good is Your Algorithm?

- Efficiency is the primary focus
- Computers consume 2 major resources:
  - time
  - space (as in memory)
- Lately, time has become the most precious
  - memory is fairly cheap
  - memory is usually not a constraint

Performance Measurement

Two Options:

1. Time the code when it runs on a variety of inputs
    - plot graphs + predict behaviour
    - hardware dependent
2. Count the number of operations (steps) your algorithm performs
    - plot graphs OR derive functions OR . . .
    - . . . use the big-O estimate
    - hardware independent